

PCTWORLD INTELLECTUAL PROPE
International Bt

INTERNATIONAL APPLICATION PUBLISHED UNDER

WO 9607999A1

(51) International Patent Classification ⁶ :
G09B 17/00, 5/06, 19/06, G11B 27/00

A1

(11) International Publication Number: WO 96/07999

(43) International Publication Date: 14 March 1996 (14.03.96)

(21) International Application Number: PCT/US95/11096

(22) International Filing Date: 5 September 1995 (05.09.95)

(30) Priority Data:
110883 5 September 1994 (05.09.94) IL

(71)(72) Applicants and Inventors: RUBIN LEBOWITZ, Ellen
[US/IL]; 20 Keren Hayesod Street, 47248 Ramat Hasharon
(IL). BERGMAN, Ofer [IL/IL]; 9 Najara Street, 63824 Tel
Aviv (IL).

(74) Agents: KARAS, Aaron, B. et al.; Helfgott & Karas, P.C., 60th
floor, Empire State Building, New York, NY 10118 (US).

(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH,
CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE,
KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MK,
MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI,
SK, TJ, TM, TT, UA, UG, US, UZ, VN, European patent
(AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC,
NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA,
GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW,
SD, SZ, UG).

Published

With international search report.

*Before the expiration of the time limit for amending the
claims and to be republished in the event of the receipt of
amendments.*

(54) Title: READING TUTORIAL SYSTEM

(57) Abstract

A system including a text memory (24) having stored therein digital information representing a given reading text having indices at a plurality of text-locations, a sound memory (22) having stored therein digital information representing a prerecorded speech corresponding to the given text and having indices at a plurality of speech-locations corresponding, respectively, to the plurality of text-locations, a main processor (26) associated with the sound memory and the text memory which correlates between the speech-indices and the text-indices such that each text-location and its respective speech-location are substantially simultaneously addressable, a sound processor (32) associated with the main processor which processes digital information from the sound memory and provides an output corresponding to a reproduction of the prerecorded speech, a sound producing unit (36) which plays-back the reproduced speech to a user and a rate controller (30) associated with the sound processor which controls the rate at which the speech is reproduced, wherein the sound processor maintains the pitch of the reproduced speech substantially the same as the pitch of the prerecorded speech.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

1 READING TUTORIAL SYSTEM

2 FIELD OF THE INVENTION

3 The present invention relates to reading aids in
4 general and, more particularly, to devices and methods for
5 playing back sound information corresponding to a written
6 text.

7 BACKGROUND OF THE INVENTION

8 Reading accompanied by audible speech corresponding
9 to a text being read is known to be helpful in developing
10 reading skills, particularly for elementary school children
11 reading for the first time and for children having reading
12 disabilities such as dyslexia.

13 It is appreciated that speech accompaniment is
14 helpful to the reader, since it helps the reader associate
15 the graphemes he reads with their corresponding phonemes.

16 However, it is inconvenient, expensive and often
17 impossible to provide a child with a personal tutor who will
18 read texts aloud to the child. Therefore, the desired speech
19 information is normally prerecorded on a magnetic tape or the
20 like and played back while the child is reading the
21 corresponding text. Alternatively, the speech may be
22 digitally recorded on a computer memory.

23 A fundamental problem of this method, however, is
24 that the rate of the played-back speech is rarely consistent
25 with the child's reading rate and, therefore, the above
26 mentioned association between graphemes and phonemes is
27 impaired.

28 Problems in dealing with reading disabilities are
29 outlined, for example, in "Development of Skill in Reading-
30 while-Listening", by "Margaret L. MacMahon", a Paper
31 presented at the 25th Annual Meeting of the International
32 Reading Association, St. Louis, Missouri, between May 5 and
33 May 9, 1980. The article describes experiments in which
34 speech was played-back at various rates to accompany reading
35 by children of different ages.

36 The results of these and other experiments indicate
37 that at fast play-back rates children have severe difficulty
38 in following the text, while it is believed that at very slow

1 play-back rates children tend to be bored with the reading.
2 Additionally, very slow play-back rates are expected to cause
3 inefficient reading habits. It is also appreciated that
4 reading rates vary considerably between children, even within
5 the same age group and, thus, there is no fixed rate which is
6 suitable for every child in a given group. Moreover, even if
7 on the average the speech rate is adapted to the reading rate
8 of a given child, it is not adapted to fluctuations in the
9 child's reading rate, for example due to difficulty in
10 reading certain words and phrases.

11 Playing back of prerecorded audible sounds, such as
12 speech, at a rate different from the original recording rate
13 is known in the art. When the recorded information is simply
14 played-back at a rate faster or slower than the original
15 recording rate, the pitch of the played-back sounds is higher
16 or lower than the original pitch. When the difference in
17 pitch is substantial, the reproduced audible sounds are
18 unpleasant, annoying and sometimes illegible. To overcome
19 this problem, a compensation in pitch is required.

20 U.K. Patent No. 2,229,068 describes a system for
21 playing back prerecorded audible sounds at a rate faster than
22 the original recording rate. The described system provides
23 pitch reduction compensation to maintain the played-back
24 sound substantially at the pitch of the prerecorded sound.
25 The sounds may be played-back at one of a number of discrete
26 rates, wherein appropriate pitch reduction is provided at
27 each rate.

28
29
30
31
32
33
34
35
36
37
38

SUMMARY OF THE INVENTION

The present invention seeks to provide a reading tutorial system which plays-back to a user at a controllable rate prerecorded sound information, preferably speech, while a corresponding reading text is being read by the user. According to the present invention, the prerecorded sound information is played back at a controllable rate, preferably at a rate adapted for the reading rate of the user. Adaptation of the play-back rate to the user's reading rate enables the user to more efficiently associate phonemes of the speech with corresponding graphemes of the text. Regular use of the present tutorial system is expected, in the long run, to improve reading skills of the user, such as phonological awareness and grapheme to phoneme translation ability.

In a preferred embodiment of the present invention, information representing the reading text is stored in a text memory, while information representing the corresponding speech is stored in a sound memory. The text and sound memories are preferably both read-only computer memories and the memories are preferably both indexed in accordance with a preselected indexing scheme. According to the present invention, the sound and text memories are correlated such that reference by the user to a given location in one of the memories is accompanied by automatic reference of the system to the corresponding location in the other memory. Thus, for example, when the user selects a location in the text where reading is to begin, the system plays-back the accompanying speech starting from a speech-location corresponding to the selected text-location. Additionally, the correlation between the sound memory and the text memory enables on-line indication of the text location corresponding to the speech location being played-back.

According to one aspect of the present invention, the play-back rate is controlled by the user, preferably using a rate control member, such that the sound information is played-back substantially in accordance with the reading rate

1 of the user. According to another aspect of the present
2 invention, the play-back rate is automatically controlled
3 based on predetermined criteria, preferably criteria related
4 to the actual reading rate.

5 There is thus provided in accordance with a preferred
6 embodiment of the invention, a reading tutorial system
7 including:

8 a text memory having stored therein digital
9 information representing a given reading text having indices
10 at a plurality of text-locations;

11 a sound memory having stored therein digital
12 information representing a prerecorded speech corresponding
13 to the given text and having indices at a plurality of
14 speech-locations corresponding, respectively, to the
15 plurality of text-locations;

16 a main processor associated with the sound memory and
17 the text memory which correlates between the speech-indices
18 and the text-indices such that each text-location and its
19 respective speech-location are substantially simultaneously
20 addressable;

21 a sound processor associated with the main processor
22 which processes digital information from the sound memory and
23 provides an output corresponding to a reproduction of the
24 prerecorded speech;

25 a sound producing unit which plays-back the
26 reproduced speech to a user; and

27 a rate controller associated with the sound processor
28 which controls the rate at which the speech is reproduced,

29 wherein the sound processor maintains the pitch of
30 the reproduced speech substantially the same as the pitch of
31 the prerecorded speech.

32 According to one preferred embodiment of the
33 invention, the rate controller is controlled manually by the
34 user to provide a desired play-back rate. The play-back rate
35 may be selected from a plurality of discrete rates or the
36 play-back rate may be continuously selectable.

37 According to another preferred embodiment of the
38 invention, the rate controller includes eye-tracking

1 apparatus which determines the actual reading rate of the
2 user and wherein the play-back rate is automatically adapted
3 to the actual reading rate.

4 In a preferred embodiment, the system further
5 includes a display for displaying the reading text to the
6 user. The display preferably includes a visual indicator
7 which indicates to the user the text-location corresponding
8 to a speech-location currently being played-back.

9 In a preferred embodiment, the sound processor
10 includes a digital signal processor.

11 According to a preferred embodiment of the invention,
12 for a given played-back speech rate, the processing rate of
13 the sound processor varies in accordance with predetermined
14 criteria dependent on characteristics of the prerecorded
15 speech. Preferably, for played-back speech rates higher than
16 the prerecorded speech rate, information representing
17 consonants is processed at a rate lower than the processing
18 rate of information representing vowels, and, for played-back
19 speech rates lower than the prerecorded speech rate,
20 information representing consonants is processed at a rate
21 higher than the processing rate of information representing
22 vowels.

23 In accordance with an alternative, preferred,
24 embodiment of the present invention, there is provided a
25 reading tutorial system including:

26 a text memory having stored therein digital
27 information representing a given reading text having indices
28 at a plurality of text-locations;

29 a sound memory including a plurality of speech files,
30 each speech file having stored therein digital information
31 representing a digital reproduction of a prerecorded speech
32 corresponding to the given text and having indices at a
33 plurality of speech-locations corresponding, respectively, to
34 the plurality of text-locations;

35 a main processor associated with the sound memory and
36 the text memory which correlates between the speech-indices
37 and the text-indices such that each text-location and its
38 respective speech-location in any of the speech files are

1 substantially simultaneously addressable;
2 a rate selector associated with the sound processor
3 which selects the speech file from which the reproduced
4 speech is to be played back; and
5 a sound producing unit which plays-back the
6 reproduced speech to a user,
7 wherein each of the speech files defines a different,
8 predetermined, reproduced speech rate.

9 According to one variation of this embodiment of the
10 invention, each speech file is a preprocessed speech file
11 containing a digital reproduction of the prerecorded speech
12 at a different, predetermined, respective, reproduced speech
13 rate but at substantially the same pitch, and wherein all the
14 speech files are reproduced from the same prerecorded speech.

15 According to another variation of this embodiment of
16 the invention, each speech file contains a digital
17 reproduction of a different, respective, prerecorded speech
18 having a predetermined, respective, prerecorded speech rate.

19 In either of the above variations, the rate selector
20 is preferably controlled manually by the user to provide a
21 desired reproduced speech rate.

22 In one preferred embodiment of the present invention,
23 the sound memory and the text memory are both contained in a
24 single read-only-memory (ROM) unit. Preferably, the ROM unit
25 includes a CD-ROM unit. The CD-ROM unit preferably includes
26 an optical disc.

27 In another preferred embodiment of the invention, the
28 sound memory and the text memory are both contained in a
29 multi-user accessible memory unit.

30 Further, in accordance with a preferred embodiment of
31 the present invention there is provided a method for
32 assisting a user in reading a given reading text including
33 the steps of:

34 storing digital information representing the given
35 reading text indexed at a plurality of text-locations;

36 storing digital information representing a
37 prerecorded speech corresponding to the given text with
38 indices at a plurality of speech-locations corresponding,

1 respectively, to the plurality of text-locations;
2 correlating between the speech-indices and the text-
3 indices such that each text-location and its respective
4 speech-location are substantially simultaneously addressable;
5 processing digital information from the sound memory
6 and providing an output corresponding to a reproduction of
7 the prerecorded speech;

8 playing-back the reproduced speech to the user;
9 controlling the rate at which the speech is
10 reproduced; and

11 maintaining the pitch of the reproduced speech
12 substantially the same as the pitch of the prerecorded
13 speech.

14 According to one preferred embodiment of the
15 invention, the step of controlling the play-back rate
16 includes the step of manually controlling the play-back rate.
17 Preferably, the step of manually controlling the play-back
18 rate includes the step of selecting the play-back rate from a
19 plurality of discrete rates. Alternatively, the play-back
20 rate is continuously selectable.

21 According to another preferred embodiment of the
22 invention, the step of controlling the play-back rate
23 includes the steps of determining the actual reading rate of
24 the user and automatically adapting the play-back rate to the
25 actual reading rate. Preferably, the step of determining the
26 actual reading rate includes the step of tracking the eye
27 movement of the user.

28 In a preferred embodiment of the invention, the
29 method further includes the step of displaying the reading
30 text to the user. Preferably, the step of displaying includes
31 the step of visually indicating to the user the text-location
32 corresponding to a speech-location currently being played-
33 back.

34 The method of the present invention may be used for
35 teaching reading, for assisting reading of users having an
36 eyesight disability, for assisting the reading of users
37 having a reading disability and for teaching languages.

38 In a preferred embodiment, the method further

1 includes the step of supervising the user by determining
2 whether the user follows the text and the speech. The step of
3 supervising preferably includes the steps of introducing
4 occasional inconsistencies between the text and the speech
5 and determining whether the inconsistencies are detected by
6 the user.

7 In an additionally preferred embodiment of the
8 present invention, the step of playing-back the reproduced
9 speech includes the step of playing-back the reproduced
10 speech at a predetermined volume level which excites the user
11 phonologically and semantically.

12 In a preferred embodiment of the invention, the step
13 of correlating between the speech-indices and the text-
14 indices includes the step of addressing a speech-location
15 corresponding to a text-location selected by the user.
16 Additionally or alternatively, in a preferred embodiment, the
17 step of correlating between the speech-indices and the text-
18 indices includes the step of addressing a text-location
19 corresponding to a given speech-location.

20 In accordance with an alternative embodiment of the
21 present invention, there is provided a method for assisting a
22 user in reading a given reading text including the steps of:

23 storing digital information representing the given
24 reading text indexed at a plurality of text-locations;

25 storing a plurality of speech files, each speech file
26 containing digital information representing a reproduction of
27 a prerecorded speech corresponding to the given text and each
28 speech file having indices at a plurality of speech-locations
29 corresponding, respectively, to the plurality of text-
30 locations;

31 correlating between the speech-indices and the text-
32 indices such that each text-location and its respective
33 speech-location in any of the speech files are substantially
34 simultaneously addressable;

35 selecting the speech file from which the reproduced
36 speech is to be played back; and

37 playing-back the reproduced speech to the user,
38 wherein each speech file defines a different,

1 respective, reproduced speech rate.

2 One variation of this embodiment of the invention,
3 further includes, in order to create each speech file, the
4 step of preprocessing the prerecorded speech at a different,
5 predetermined, respective, reproduced speech rate but at
6 substantially the same pitch, wherein all the speech files
7 are preprocessed from the same prerecorded speech.

8 Another variation of this embodiment of the invention
9 further includes, in order to create each of the speech
10 files, the step of digitally reproducing a different,
11 respective, prerecorded speech having a predetermined,
12 respective, prerecorded speech rate.

13 In accordance with a further, preferred, embodiment
14 of the present invention, there is provided a read-only-
15 memory (ROM) including:

16 a text memory having stored therein digital
17 information representing a given reading text having indices
18 at a plurality of text-locations; and

19 a sound memory having stored therein digital
20 information representing a prerecorded speech corresponding
21 to the given text and having indices at a plurality of
22 speech-locations corresponding, respectively, to the
23 plurality of text-locations.

24 In accordance with another, preferred, embodiment of
25 the present invention, there is provided a read-only-memory
26 (ROM) including:

27 a text memory having stored therein digital
28 information representing a given reading text having indices
29 at a plurality of text-locations; and

30 a sound memory including a plurality of speech files,
31 each speech file having stored therein digital information
32 representing a digital reproduction of a prerecorded speech
33 corresponding to the given text and having indices at a
34 plurality of speech-locations corresponding, respectively, to
35 the plurality of text-locations.

36 In a preferred embodiment of the present invention,
37 the ROM includes a CD-ROM. Preferably, the CD-ROM includes an
38 optical disc.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood from the following detailed description of preferred embodiments of the invention, taken in conjunction with the following drawings in which:

Fig. 1 is a simplified, pictorial, illustration of a reading tutorial system constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 2 is a schematic block diagram functionally illustrating the system of Fig. 1; and

Fig. 3 is a simplified, pictorial, illustration of a reading tutorial system constructed and operative in accordance with an alternative, preferred, embodiment of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is now made to Fig. 1, which schematically illustrates a reading tutorial system in accordance with a preferred embodiment of the present invention. The system preferably includes a central processing unit (CPU) 10 associated with a display 12 and a mouse 14 as known in the art. In a preferred embodiment of the present invention, the system further includes a sound producing device associated with CPU 10 and preferably including a head-set 20 adapted for a user 18. According to one embodiment of the present invention the system also includes a rate control pedal 16 operated by user 18 as described below.

During operation of the system, user 18 reads a preselected text which is preferably displayed on display 12. A curser or other movable visual indicator, which may be controlled by mouse 14 or using a keyboard as known in the art, is preferably displayed together with the text on display 12. According to the present invention, a speech corresponding to the text being read by user 18 are played-back to the user via head-set 20 at a rate controlled by user 18 using rate controller 16. In a preferred embodiment of the invention, the curser or other visual indication moves along the text on display 12 according to the rate of the played-

1 back speech.

2 Reference is now made to Fig. 2 which functionally
3 illustrates the system of Fig. 1. As shown in Fig. 2, the
4 system preferably includes a sound memory 22 and a text
5 memory 24, both of which are associated with a central
6 processing unit (CPU) 26 which addresses the information
7 stored in the memories. Memories 22 and 24 may be physically
8 embodied in two, separate, digital memory units or in a
9 single memory unit, as known in the art. Since the
10 information stored in memories 22 and 24 is preferably fixed,
11 read-only-memories (ROM) are preferably used, inter alia, to
12 prevent user 18 from changing the stored information
13 intentionally or accidentally. CPU 26 is preferably
14 associated with a visual display 34 which displays the
15 processed reading text and, via a digital signal processor
16 (DSP) 32 and a digital-to-analog (D/A) converter 33, with a
17 sound producing unit 36 which generates an audible
18 reproduction of the prerecorded speech. Sound producing unit
19 36 is preferably associated with head-set 20 of user 18.
20 Display 34 preferably includes a computer screen as indicated
21 by reference numeral 12 in Fig. 1.

22 Text memory 24 is used for storing digital
23 information representing a given reading text, such as the
24 content of a book, an essay or a reading exercise. According
25 to a preferred embodiment of the invention, the text stored
26 in memory 24 is indexed at preselected locations so as to
27 enable access by CPU 26 to given locations of the text stored
28 in memory 24. Any suitable indexing scheme may be used, for
29 example indices may be provided at the beginning of each
30 letter, syllable, word or sentence, so as to achieve a
31 predetermined resolution in accessing the stored text.

32 In accordance with a preferred embodiment of the
33 present invention, sound memory 22 is used for storing
34 digital information representing a prerecorded speech
35 corresponding to the text stored in text memory 24. The
36 speech stored in memory 22 is preferably indexed in
37 accordance with the indexing scheme used for the text in
38 memory 24. For example, if the information in memory 24 is

1 indexed at the beginning of each word of the text, the
2 information in memory 22 is preferably indexed at the
3 beginning of each, respective, word of the corresponding
4 prerecorded speech.

5 As mentioned above, memories 22 and 24 may be
6 embodied in separate memory units or both memories may be
7 included in a single memory unit, preferably a read-only-
8 memory (ROM) unit. In accordance with one preferred
9 embodiment of the present invention, the speech information
10 of memory 22 and the text information of memory 24 are both
11 stored on a single CD-ROM unit, preferably including a
12 compact optical disc. It should be appreciated that such CD-
13 ROM units are capable of storing large volumes of speech and
14 text information. The speech and text information stored on
15 the CD-ROM unit is preferably indexed as described above.

16 In accordance with another preferred embodiment of
17 the present invention, the speech information of memory 22
18 and the text information of memory 24 are part of a central
19 memory unit, such as a data-base. In this preferred
20 embodiment of the invention, the speech and text information
21 may be retrieved from the central memory unit by multiple
22 users, using any known computer communication system or
23 network. For example, the speech and text information may be
24 stored in a data-base connected to InterNet.

25 During operation, CPU 26 reads text information from
26 memory 24 and corresponding speech information from memory
27 22. Pointer circuitry in CPU 26 correlates between the
28 indices of the text information and the corresponding indices
29 of the sound information, such that respective indices of
30 memories 22 and 24 may be addressed simultaneously. When CPU
31 26 is directed by user 18 to address a desired location in
32 the text, as described below, the above mentioned pointer
33 circuitry also addresses the corresponding location in the
34 speech to be played-back.

35 As further shown in Fig. 2, CPU 26 is associated with
36 a rate controller 30 which may be foot-operated, as shown by
37 reference numeral 16 in Fig. 1, or hand-operated, for
38 example, through appropriately defined functions of mouse 14

1 (Fig. 1). A analog-to-digital (A/D) converter is preferably
2 employed to convert the generally analog output of rate
3 controller 30 to a corresponding digital output readable by
4 CPU 26. In accordance with the present invention, CPU 26
5 controls the rate of data processing by DSP 32 based on the
6 input from rate controller 30. For example, in the embodiment
7 of Fig. 1, the position of pedal 16 controls the output of
8 the pedal and, thus, controls the processing rate of sound-
9 bearing data by DSP 32.

10 As known in the art, DSP 32 processes the sound-
11 bearing digital data and D/A 33 generates a corresponding
12 analog output to sound producing unit 36. The circuitry of
13 sound producing unit 36 may include amplifiers, filters,
14 etc., as required for reproducing the prerecorded speech
15 through speakers (not shown) and/or head-set 20 (Fig. 1). It
16 should be appreciated that the play-back rate of the
17 reproduced speech is determined by the rate at which sound-
18 bearing data is processed by DSP 32 and, therefore, the play-
19 back rate is controlled by user 18 using rate controller 30.

20 The data output rate of DSP 32 varies in accordance
21 with the desired play-back rate, such that the data output
22 rate is higher for higher play-back rates and lower for lower
23 play-back rates. Alternatively, if DSP 32 is designed to
24 output digital information at a given rate, down-sampling of
25 the sound-bearing digital data, i.e. processing of only part
26 of the digital data, may be used for play-back rates higher
27 than the original speech rate.

28 To maintain the desired data output rate for play-
29 back rates lower than the original speech rate, DSP 32
30 preferably up-samples the sound-bearing digital data, i.e.
31 generates additional samples which may be duplicates of
32 adjacent existing samples or otherwise dependent on existing
33 samples. If up-sampling is not used, the data output rate of
34 DSP 32 varies in accordance with the desired play-back rate.

35 It is appreciated that, in natural speech, changes in
36 rate may be inhomogeneous, e.g. the time-span of vowels is
37 generally more dependent on the speech rate than the time
38 span of consonants. Thus, in a preferred embodiment of the

1 present invention, changes in played-back speech rate are
2 not homogeneous. For example, changes in the processing rate
3 of data strings representing consonants may be different
4 from, and generally proportionally lower than, changes in
5 the processing rate of data strings representing vowels. To
6 distinguish between different speech elements, such as vowels
7 and consonants, the corresponding data-strings may be marked
8 to indicate the appropriate changes in processing rate
9 required for each data-string.

10 It is appreciated, however, that the pitch of the
11 played-back speech varies with the play-back rate, i.e. the
12 higher the play-back rate the higher the pitch. Thus,
13 according to the present invention, the pitch of the played-
14 back speech is controlled in accordance with the play-back
15 rate. The pitch is preferably controlled by pitch
16 compensation circuitry which receives from CPU 26 a pitch
17 control input responsive to the play-back rate and provides
18 appropriate pitch compensation. Since the required change in
19 pitch is uniquely determined by the change in play-back-rate,
20 pitch compensation may be based on a predetermined formula
21 executed by the pitch compensation circuitry, as known in the
22 art. The pitch compensation circuitry may be included in DSP
23 32, as shown in Fig. 2, or it may be provided in a separate
24 unit preceding or following DSP 32.

25 A preferred sequence of operation of the present
26 tutorial system will now be described, referring also to Fig.
27 1. User 18 uses mouse 14 to select a preselected portion of
28 the reading text to appear on display 34. The exact location
29 from which reading is to begin is preferably highlighted or
30 otherwise distinguished on display 34 as known in the art.
31 The pointer circuitry of CPU 26 identifies the index of the
32 selected location in text memory 24 and addresses the
33 corresponding index in speech memory 22. Thus, the
34 prerecorded speech is played-back starting from the location
35 selected by user 18. In a preferred embodiment of the
36 invention, the highlighted location in the displayed text,
37 which may be a letter, a syllable, a word, etc., moves in
38 accordance with the play-back rate of the corresponding

1 speech.

2 It should be appreciated that due to the indexing
3 scheme which correlates between memories 22 and 24, user 18
4 can use mouse 14 to "hop" to any desired location in the
5 text, preceding or succeeding the initial location, while
6 listening to the corresponding speech location after each
7 "hop".

8 If the initial play-back rate is unsuitable for user
9 18, i.e. too fast or too slow, user 18 changes the play back
10 rate using rate controller 30. The pitch of the played-back
11 speech is preferably substantially constant, due to the
12 automatic pitch compensation described above. This,
13 preferably on-line, control of the play-back rate ensures
14 that the prerecorded speech is played-back to the user at a
15 rate adapted for his or her specific reading skills and/or
16 habits.

17 In a preferred embodiment of the invention, rate
18 controller 30 provides continuous rate control. However, in a
19 simpler system, controller 30 may be embodied as a multi-
20 position switch, wherein a plurality of discrete play-back
21 rates are defined by the different switch positions.
22 Alternatively, the play-back rate may be selected from a menu
23 appearing on display 34 using a keyboard (not shown) or mouse
24 14.

25 In an alternative, preferred, embodiment of the
26 present invention, changes in the speech rate and appropriate
27 pitch compensations are performed off-line rather than on-
28 line. According to this embodiment, preprocessed files
29 corresponding to a plurality of different play-back rates of
30 the prerecorded speech are stored separately in speech
31 memory 22. To correlate between the preprocessed files and
32 the text in memory 24, each of the preprocessed files is
33 preferably indexed in accordance with the indexing scheme of
34 text memory 24. At any given time during operation of the
35 system, sound information is retrieved from one of the
36 preprocessed files which corresponds to the play-back rate
37 selected by user 18 from a preselected menu, for example by
38 using a multi-position switch as described above. In a

1 preferred embodiment of the invention, the speech location
2 being played-back is substantially unaffected by changes in
3 the play-back rate, as described below.

4 Since each preprocessed file preferably corresponds
5 to a constant play-back rate, having a predetermined constant
6 ratio relative to the original, prerecorded, speech rate,
7 the ratios between the play-back rates of the different
8 preprocessed files are also constant and predeterminable.
9 Thus, based on a given speech location in a given
10 preprocessed file, it is possible to accurately determine a
11 corresponding speech location in any of the other
12 preprocessed files. For example, if the ratio between the
13 play-back rates of two preprocessed files is 2:1, there is a
14 time ratio of 2:1 between corresponding speech locations of
15 the two files. This time ratio is preferably applied to
16 maintain a correct speech location when the user switches
17 between the different play-back rates.

18 Alternatively, since the same indexing scheme is
19 preferably used for all of the preprocessed files, the
20 indexing of the preprocessed files can be utilized to
21 maintain the correct speech location when the play-back rate
22 is changed by user 18.

23 To obtain the preprocessed files, processing as
24 described above is preferably employed to change the speech
25 rate and to provide appropriate pitch compensation for each
26 file. For example, down-sampling or up-sampling as described
27 above can be used. The preprocessed files are then stored
28 separately in speech memory 22. Therefore, no further
29 processing is required, on-line, to provide the desired play-
30 back rate and appropriate pitch compensation during
31 operation.

32 In a further, preferred, embodiment of the invention,
33 a plurality of prerecordings of the original speech are used
34 for providing the different speech rates, whereby the text is
35 read at a different, preselected, speech rate during each
36 prerecording. The prerecorded speeches are then stored
37 separately in speech memory 22, e.g. in separate files. The
38 provision of a plurality of preselected actual speech rates,

1 at the prerecording stage, obviates the need for processing
2 as in the above embodiments to provide different play-back
3 rates. During operation, the prerecorded speeches are
4 retrieved from speech memory 22, in accordance with the rate-
5 selections of user 18, as described above with reference to
6 the embodiment in which preprocessed files are used. The same
7 indexing scheme is preferably used for all the prerecorded
8 speeches so as to maintain the correct speech location when
9 user 18 switches between different speech rates.

10 According to another preferred embodiment of the
11 present invention, not shown in the drawings, the play back
12 rate is controlled automatically using an eye-tracking
13 system. For example, as shown in Fig. 3, the eye tracking
14 system may include an optical sensor 40, such as a video
15 camera, which follows the movement of the pupils of user 18.
16 The output of optical sensor 40 is preferably processed by
17 appropriate rate-control circuitry in controller 30 or CPU
18 26. According to this embodiment of the invention, user 18
19 simply reads the text while the accompanying speech is
20 automatically played-back at the actual reading rate of the
21 user. Eye-tracking devices as required for this preferred
22 embodiment of the present invention are known in the art.

23 According to a further, preferred, embodiment of the
24 present invention, the reading tutorial system provides means
25 for supervising the user by determining whether the user
26 follows the text and the speech with sufficient
27 concentration. This can be achieved, for example, by
28 introducing occasional inconsistencies between the text and
29 the speech, whereby the user is required to provide a
30 preselected active response each time an inconsistency is
31 detected.

32 Reference is again made to Fig. 2. In a preferred
33 embodiment of the present invention, the sounds produced by
34 sound producing unit 36 are volume-controlled, for example by
35 an appropriate control button on unit 36. According to this
36 preferred embodiment, the speech accompaniment can be played-
37 back at very low volume levels so as to cause subliminal
38 phonological and semantic excitation of the user, as known in

1 the art. With such low volume speech accompaniment, the user
2 is prevented from being fully dependent on the played-back
3 speech during reading.

4 It should be appreciated that use of the present
5 reading tutorial system is not limited to improvement of
6 reading skills among school children. In fact, the present
7 invention may be equally suitable for a variety of other
8 uses, for example learning of new languages, assisting
9 reading of people having poor eyesight and/or reading
10 disabilities such as dyslexia.

11 Speech memory 22 and text memory 24 may be
12 implemented form of memory known in the art, such information
13 may be stored using any suitable memory. For example, both
14 the text and sound memory

15 It will be appreciated by persons skilled in the art
16 that the present invention is not limited to what has been
17 thus far described. Rather, the scope of the present
18 invention is limited only by the following claims:

19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38

C L A I M S

1. A reading tutorial system comprising:
 - a text memory having stored therein digital information representing a given reading text having indices at a plurality of text-locations;
 - a sound memory having stored therein digital information representing a prerecorded speech corresponding to the given text and having indices at a plurality of speech-locations corresponding, respectively, to the plurality of text-locations;
 - a main processor associated with the sound memory and the text memory which correlates between the speech-indices and the text-indices such that each text-location and its respective speech-location are substantially simultaneously addressable;
 - a sound processor associated with the main processor which processes digital information from the sound memory and provides an output corresponding to a reproduction of the prerecorded speech;
 - a sound producing unit which plays-back the reproduced speech to a user; and
 - a rate controller associated with the sound processor which controls the rate at which the speech is reproduced, wherein the sound processor maintains the pitch of the reproduced speech substantially the same as the pitch of the prerecorded speech.
2. A system according to claim 1 wherein the rate controller is controlled manually by the user to provide a desired play-back rate.
3. A system according to claim 2 wherein the play-back rate is selected from a plurality of discrete rates.
4. A system according to claim 2 wherein the play-back rate is continuously selectable.

1 5. A system according to claim 1 wherein the rate
2 controller comprises eye-tracking apparatus which determines
3 the actual reading rate of the user and wherein the play-back
4 rate is automatically adapted to the actual reading rate.

5
6 6. A system according to any of the preceding claims
7 wherein the sound processor comprises a digital signal
8 processor.

9
10 7. A system according to any of claims 1-5 wherein, for
11 a given played-back speech rate, the processing rate of the
12 sound processor varies in accordance with predetermined
13 criteria dependent on characteristics of the prerecorded
14 speech.

15
16 8. A system according to claim 7 wherein, for played-
17 back speech rates higher than the prerecorded speech rate,
18 information representing consonants is processed at a rate
19 lower than the processing rate of information representing
20 vowels, and, for played-back speech rates lower than the
21 prerecorded speech rate, information representing consonants
22 is processed at a rate higher than the processing rate of
23 information representing vowels.

24
25 9. A reading tutorial system comprising:
26 a text memory having stored therein digital
27 information representing a given reading text having indices
28 at a plurality of text-locations;
29 a sound memory including a plurality of speech files,
30 each speech file having stored therein digital information
31 representing a digital reproduction of a prerecorded speech
32 corresponding to the given text and having indices at a
33 plurality of speech-locations corresponding, respectively, to
34 the plurality of text-locations;
35 a main processor associated with the sound memory and
36 the text memory which correlates between the speech-indices
37 and the text-indices such that each text-location and its
38 respective speech-location in any of the speech files are

1 substantially simultaneously addressable;
2 a rate selector associated with the sound processor
3 which selects the speech file from which the reproduced
4 speech is to be played back; and
5 a sound producing unit which plays-back the
6 reproduced speech to a user,
7 wherein each of the speech files defines a different,
8 predetermined, reproduced speech rate.
9

10 10. A system according to claim 9 wherein at least one
11 speech file is a preprocessed speech file containing a
12 digital reproduction of the prerecorded speech at a
13 different, predetermined, respective, reproduced speech rate
14 but at substantially the same pitch, and wherein all the
15 speech files are reproduced from the same prerecorded speech.
16

17 11. A system according to claim 9 wherein at least one
18 speech file contains a digital reproduction of a different,
19 respective, prerecorded speech having a predetermined,
20 respective, prerecorded speech rate.
21

22 12. A system according to any of claims 9-11 wherein the
23 rate selector is controlled manually by the user to provide a
24 desired reproduced speech rate.
25

26 13. A system according to any of claims 9-11 and further
27 comprising a display for displaying the reading text to the
28 user.
29

30 14. A system according to claim 13 wherein the display
31 comprises a visual indicator which indicates to the user the
32 text-location corresponding to a speech-location currently
33 being played-back.
34

35 15. A system according to any of claims 1-5 or 9-11
36 wherein said sound memory and said text memory are both
37 contained in a single read-only-memory (ROM) unit.
38

1 16. A system according to claim 15 wherein the ROM unit
2 comprises a CD-ROM unit.

3

4 17. A system according to claim 16 wherein the CD-ROM
5 unit comprises an optical disc.

6

7 18. A system according to any of claims 1-5 or 9-11
8 wherein said sound memory and said text memory are both
9 contained in a multi-user accessible memory unit.

10

11 19. A method for assisting a user in reading a given
12 reading text comprising the steps of:

13 storing digital information representing the given
14 reading text indexed at a plurality of text-locations;

15 storing digital information representing a
16 prerecorded speech corresponding to the given text with
17 indices at a plurality of speech-locations corresponding,
18 respectively, to the plurality of text-locations;

19 correlating between the speech-indices and the text-
20 indices such that each text-location and its respective
21 speech-location are substantially simultaneously addressable;

22 processing digital information from the sound memory
23 and providing an output corresponding to a reproduction of
24 the prerecorded speech;

25 playing-back the reproduced speech to the user;

26 controlling the rate at which the speech is
27 reproduced; and

28 maintaining the pitch of the reproduced speech
29 substantially the same as the pitch of the prerecorded
30 speech.

31

32 20. A method according to claim 19 wherein the step of
33 controlling the play-back rate comprises the step of manually
34 controlling the play-back rate.

35

36 21. A method according to claim 20 wherein the step of
37 manually controlling the play-back rate comprises the step of
38 selecting the play-back rate from a plurality of discrete

1 rates.

2

3 22. A method according to claim 21 wherein the play-back
4 rate is continuously selectable.

5

6 23. A method according to claim 19 wherein the step of
7 controlling the play-back rate comprises the steps of
8 determining the actual reading rate of the user and
9 automatically adapting the play-back rate to the actual
10 reading rate.

11

12 24. A method according to claim 23 wherein the step of
13 determining the actual reading rate comprises the step of
14 tracking the eye movement of the user.

15

16 25. A method for assisting a user in reading a given
17 reading text comprising the steps of:

18 storing digital information representing the given
19 reading text indexed at a plurality of text-locations;

20 storing a plurality of speech files, each speech file
21 containing digital information representing a reproduction of
22 a prerecorded speech corresponding to the given text and each
23 speech file having indices at a plurality of speech-locations
24 corresponding, respectively, to the plurality of text-
25 locations;

26 correlating between the speech-indices and the text-
27 indices such that each text-location and its respective
28 speech-location in any of the speech files are substantially
29 simultaneously addressable;

30 selecting the speech file from which the reproduced
31 speech is to be played back; and

32 playing-back the reproduced speech to the user,

33 wherein each speech file defines a different,
34 respective, reproduced speech rate.

35

36 26. A method according to claim 25 and further
37 comprising, to create each speech file, the step of
38 preprocessing the prerecorded speech at a different,

1 predetermined, respective, reproduced speech rate but at
2 substantially the same pitch, wherein all the speech files
3 are preprocessed from the same prerecorded speech.
4

5 27. A method according to claim 25 and further
6 comprising, to create each of the speech files, the step of
7 digitally reproducing a different, respective, prerecorded
8 speech having a predetermined, respective, prerecorded speech
9 rate.
10

11 28. A method according to any of claims 19 - 27 and
12 further comprising the step of displaying the reading text to
13 the user.
14

15 29. A method according to claim 28 wherein the step of
16 displaying comprises the step of visually indicating to the
17 user the text-location corresponding to a speech-location
18 currently being played-back.
19

20 30. A method according to any of claims 19 - 27 used for
21 teaching reading.
22

23 31. A method according to any of claims 19 - 27 used for
24 assisting reading of users having an eyesight disability.
25

26 32. A method according to any of claims 19 - 27 used for
27 assisting the reading of users having a reading disability.
28

29 33. A method according to any of claims 19 - 27 used for
30 teaching a language.
31

32 34. A method according to any of claims 19 - 27 and
33 further comprising the step of supervising the user by
34 determining whether the user follows the text and the speech.
35

36 35. A method according to claim 34 wherein the step of
37 supervising comprises the steps of introducing occasional
38 inconsistencies between the text and the speech and

1 determining whether the inconsistencies are detected by the
2 user.

3
4 36. A method according to any of claims 19 - 27 wherein
5 the step of playing-back the reproduced speech comprises the
6 step of playing-back the reproduced speech at a predetermined
7 volume level which excites the user phonologically and
8 semantically.

9
10 37. A method according to any of claims 19 - 27 wherein
11 the step of correlating between the speech-indices and the
12 text-indices comprises the step of addressing a speech-
13 location corresponding to a text-location selected by the
14 user.

15
16 38. A method according to any of claims 19 - 27 wherein
17 the step of correlating between the speech-indices and the
18 text-indices comprises the step of addressing a text-location
19 corresponding to a given speech-location.

20
21 39. A read-only-memory (ROM) comprising:
22 a text memory having stored therein digital
23 information representing a given reading text having indices
24 at a plurality of text-locations; and
25 a sound memory having stored therein digital
26 information representing a prerecorded speech corresponding
27 to the given text and having indices at a plurality of
28 speech-locations corresponding, respectively, to the
29 plurality of text-locations.

30
31 40. A read-only-memory (ROM) comprising:
32 a text memory having stored therein digital
33 information representing a given reading text having indices
34 at a plurality of text-locations; and
35 a sound memory including a plurality of speech files,
36 each speech file having stored therein digital information
37 representing a digital reproduction of a prerecorded speech
38 corresponding to the given text and having indices at a

1 plurality of speech-locations corresponding, respectively, to
2 the plurality of text-locations.

3

4 41. A ROM according to claim 39 or claim 40 comprising a
5 CD-ROM.

6

7 42. A ROM according to claim 41 comprising an optical
8 disc.

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

26

27

28

29

30

31

32

33

34

35

36

37

38

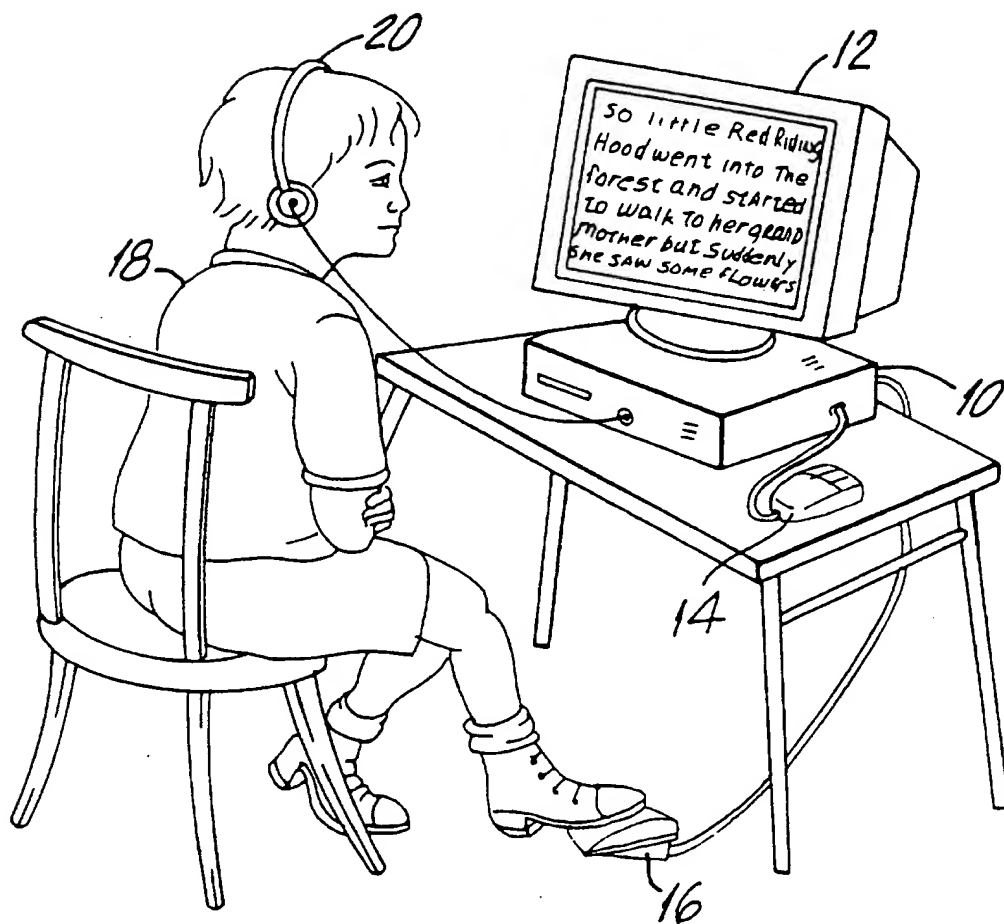
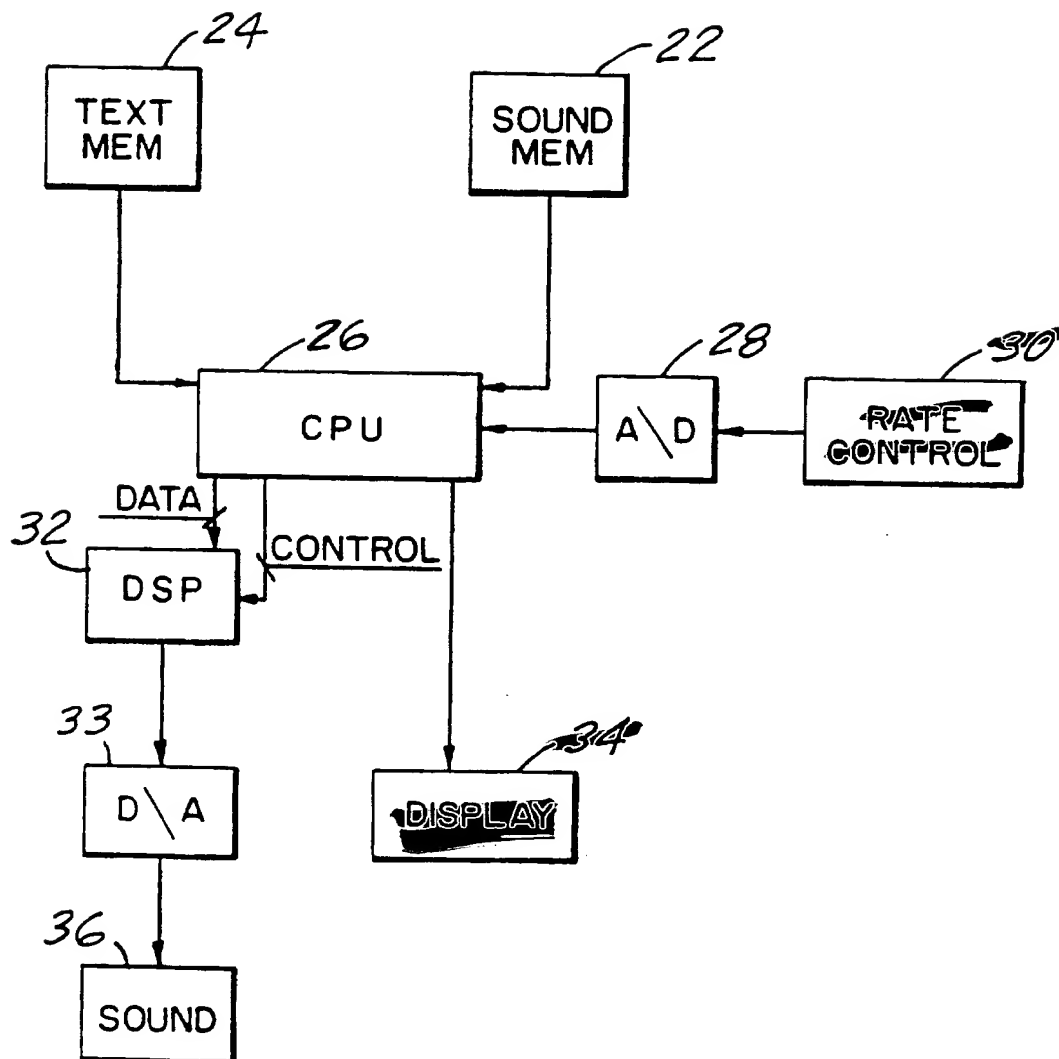


FIG. 1

**FIG. 2**

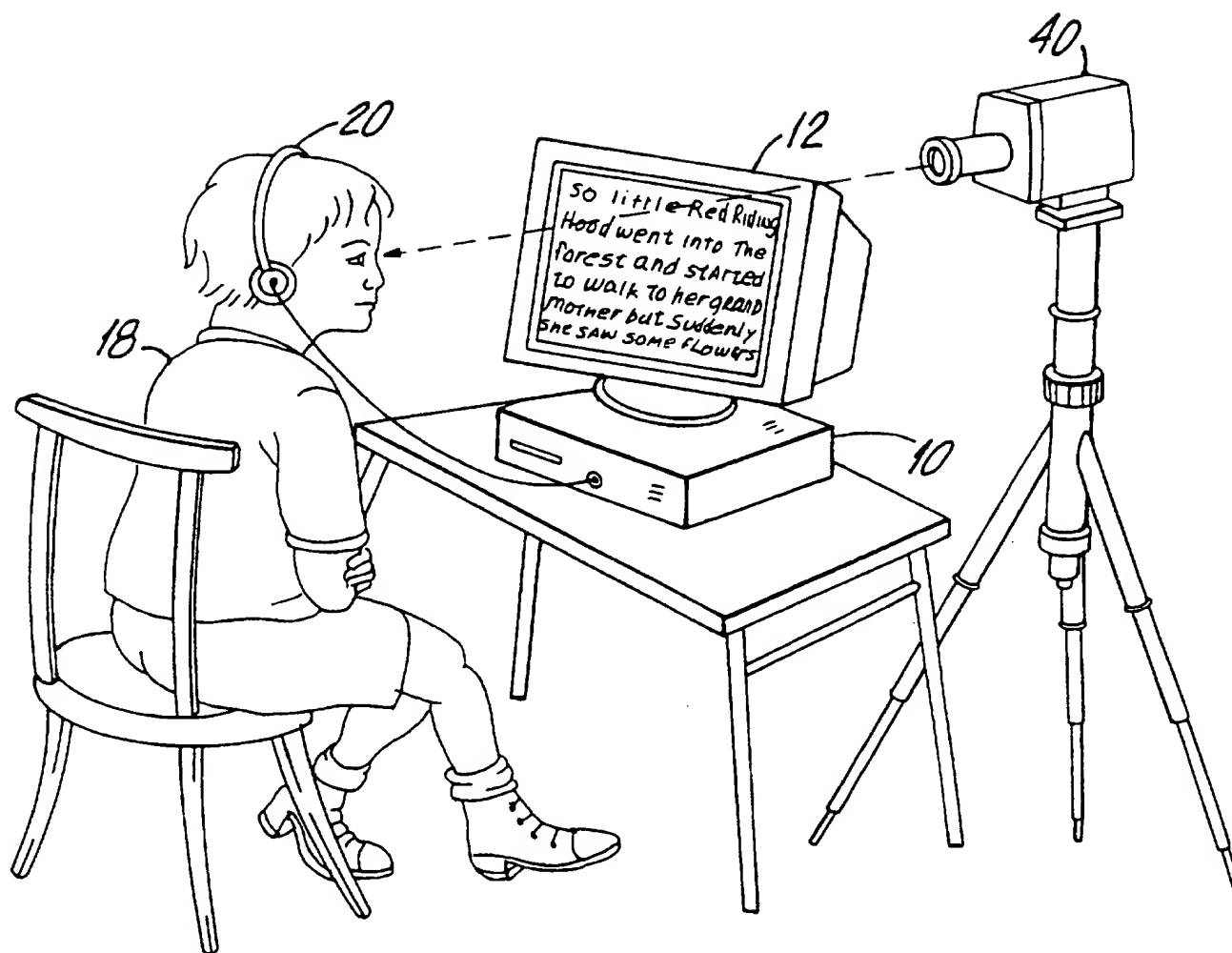


FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 95/11096

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 G09B17/00 G09B5/06 G09B19/06 G11B27/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 G09B G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, Y	WO, A, 95 09506 (READSPEAK INC) 6 April 1995	1, 9, 19, 25
A	see the whole document	6, 13-17, 28-31, 33, 37-41
Y	WO, A, 85 01377 (SONY CORP) 28 March 1985	1, 9, 19, 25
P, Y	WO, A, 94 24667 (ADVANCE KK ; ISHIBASHI HIROMU (JP)) 27 October 1994	1, 9, 19, 25

-/--

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- *&* document member of the same patent family

Date of the actual completion of the international search

9 January 1996

Date of mailing of the international search report

15. 01. 96

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
 Facs (+31-70) 340-3016

Authorized officer

Gorun, M

INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/US 95/11096

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>WO,A,93 16455 (KAMINSKI MAREK ;LEMPICKI ALEXANDER (US)) 19 August 1993</p> <p>see page 3, line 22 - page 7, line 11; claims 1,2,7</p> <p>---</p>	<p>1,9,13, 14,19, 25,33</p>
A	<p>DE,A,22 47 728 (KOCH RICHARD F) 12 April 1973</p> <p>see the whole document</p> <p>---</p>	<p>1,9,19, 25</p>
A	<p>EP,A,0 542 377 (PHILIPS ELECTRONICS UK LTD ;PHILIPS NV (NL)) 19 May 1993</p> <p>see the whole document</p> <p>---</p>	<p>1,9, 15-17, 19,38-42</p>
A	<p>WO,A,90 14652 (BEHUNIN STEPHEN O) 29 November 1990</p> <p>see page 3, last paragraph - page 13, paragraph 3</p> <p>---</p>	<p>1-3,5, 19-21, 23,24,30</p>
A	<p>EP,A,0 528 421 (SONY CORP) 24 February 1993</p> <p>see the whole document</p> <p>-----</p>	<p>1,9,15, 16</p>

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 95/11096

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-9509506	06-04-95	AU-B- 7842394	18-04-95
WO-A-8501377	28-03-85	JP-C- 1806193	26-11-93
		JP-B- 5017631	09-03-93
		JP-A- 60059570	05-04-85
		JP-C- 1797358	28-10-93
		JP-B- 5003676	18-01-93
		JP-A- 60127567	08-07-85
		AU-B- 574104	30-06-88
		AU-B- 3394784	11-04-85
		DE-A- 3484901	12-09-91
		EP-A, B 0155970	02-10-85
		HK-A- 73794	05-08-94
		SG-A- 85194	14-10-94
		US-A- 4734795	29-03-88
WO-A-9424667	27-10-94	JP-A- 6308992	04-11-94
		EP-A- 0652560	10-05-95
WO-A-9316455	19-08-93	US-A- 5273433	28-12-93
		CA-A- 2129748	11-08-93
		EP-A- 0626089	30-11-94
		JP-T- 7504516	18-05-95
DE-A-2247728	12-04-73	US-A- 3816664	11-06-74
		GB-A- 1404007	28-08-75
EP-A-0542377	19-05-93	US-A- 5301172	05-04-94
WO-A-9014652	29-11-90	US-A- 5033966	23-07-91
		AU-B- 5671790	18-12-90
		EP-A- 0425654	08-05-91
		JP-T- 3506082	26-12-91
EP-A-0528421	24-02-93	JP-A- 5046624	26-02-93